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THE DIE-BACK DISEASE OF PARA RUBBER

AND A NOTE ON THE LEAF DISEASES OF PARA RUBBER.

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BY

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Kuala Lumpur, Federated Malay States
August, 1911.

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PREFACE.

Bulletin No. 9, the title of which was "The Die-back Fungus of Cacao and of Para Rubber," was issued by the Department of Agriculture in June 1911. The work comprised an account of investigations on the fungus *Thyridaria tarda* which were commenced under the direction of Mr. George Massee, V.M.H., F.L.S., Principal Assistant at the Royal Herbarium, Kew, and Plant Pathologist to the Board of Agriculture, England, on cacao material from the West Indies and West Africa, and were completed on Para rubber in this country. The conclusions as to the parasitic action of the fungus were based on the results of investigations on its life-history. Since much of the work was necessarily of a technical nature, it was decided to issue an account of the disease in a form in which it may be of more interest to the practical cultivator, and to illustrate it with photographs and woodcuts, which it is hoped will enable the cultivator to recognise and to identify the fungus and its effects with some degree of facility; hence, the origin of this Bulletin, No. 14.

L. LEWTON-BRAIN,

Director of Agriculture, F. M. S.

August, 1911.

THE DIE-BACK DISEASE

OF

PARA RUBBER.

By Keith Bancroft, b.a. (Camb.).

THE HISTORY AND DISTRIBUTION OF THE FUNGUS.

The die-back disease of Para rubber, which is attributed to a form known as *Diplodia,* concluded to be a stage of the fungus *Thyridaria tarda,* was first recorded by Ridley* in the Federated Malay States in 1909. It also appears to be likely that Gallagher† had the same fungus in view in his "Preliminary Note on a Stem and Branch Disease of *Hevea Brasiliensis.*" Subsequently, Petch** published an account of the disease from Ceylon in 1910.

The fungus itself was first recorded on cacao‡ from Ecuador as early as 1892. Since then it has been known as a parasite on cacao in many countries and has also been recorded on several other plants in different parts of the Tropics. It possesses an almost world-wide distribution through the Tropics, occurring in the West Indies, South America, St. Thome, West Africa, India, Ceylon, the Malay Peninsula, the East Indies, Samoa and the Philippines.

As a parasite on cacao the fungus has never been regarded as being likely to cause serious damage to the industry, except perhaps in the Island of St. Thome and in Grenada (West Indies). A quantity of material was examined from both of these Islands and, from the fact that the *Diplodia* was usually associated with other parasitic

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* Agricultural Bulletin Straits Settlements and Federated Malay States, Vol. VIII, p. 310, 1909.

† Bulletin No. 6, Department of Agriculture, F.M.S.

** Circulars and Agricultural Journal, Royal Botanic Gardens, Ceylon, Vol. IV. No. 23, 1910.

‡ In order to avoid confusion with coca, cocoes, coconut, etc., the plant which yields cocoa of commerce is called by the above name, *cacao.*

fungi and from a general knowledge of the nature of the *Diplodia,* it was assumed that by no means all of the damage could be attributed to it. The fungus comes on readily on parts of plants which are dying or recently dead and possesses a capacity for very rapid growth, so that it frequently tends to mask the real cause of the trouble. In this country it has frequently been found to follow on the "pink fungus," on attacks by root fungi, and on a bad condition of health induced by inefficient drainage and bad cultivation generally. The question of its becoming epidemic has been frequently raised, and it may be accepted, from a knowledge of the capacity of the fungus for causing disease, that the fungus cannot be reasonably expected to cause any serious injury to the industry unless it follows on some other pest, epidemic in magnitude, which provides it with a ready access to the plant.

In addition to occurring on cacao and Para rubber, the fungus has been shown to be parasitic on tea, *Albizzia* and dadap in Ceylon, on sugar cane, cacao, coconut and *Castilloa elastica* in the West Indies, on mango in St. Domingo, on papaw in Samoa and on sugar cane in India. It also develops readily on dead and dying plant material of very many kinds; in fact, it is so commonly met with on dead parts of plants in this country and it effects such a rapid growth that considerable caution must be exercised in diagnosing the die-back disease. A clear idea of the symptoms must be formed along with a proof of the absence of other parasitic organisms before the effect can be attributed to the fungus with any degree of certainty. In other words, the presence of the fungus on dead or dying parts of plants is of itself no proof that the trouble has been initiated by the fungus.

The fungus has been met with in Selangor, Perak, Negri Sembilan, Johore, Pahang and Malacca. It may, therefore, be concluded to be widely distributed through the Malay Peninsula.

THE DISEASE.

The disease may commence on any portion of the stem; most usually it occurs in the region of the branches, but it may also commence on any part of the trunk. The symptoms may take the form of a "dying back" or, less frequently, a "canker" of the affected part. The fungus enters only at a dead surface, such as dead branches or parts of branches and wood which has died from exposure

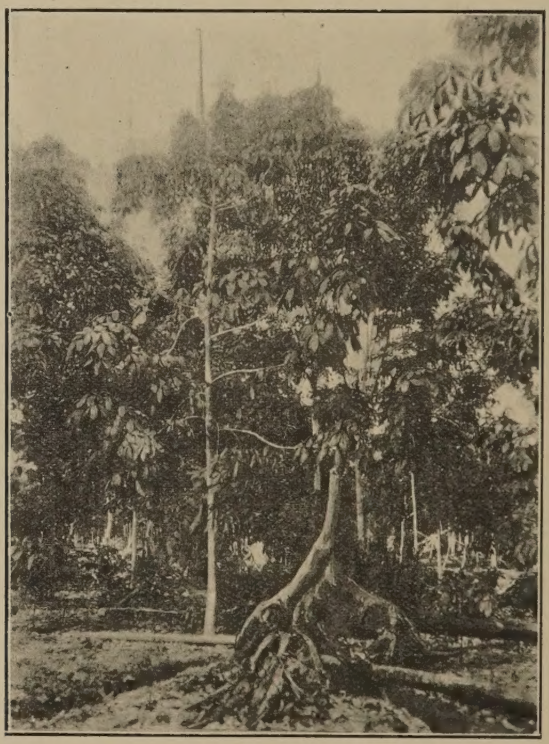
or from the action of fungi or animals. Repeated attempts to inoculate plants by applying the spores to an unbroken surface have failed. In the photograph 1 the effect of

Photograph 1.

inoculating a seedling at a wound is shown. The control plant which was not inoculated is seen to be healthy.

Usually, a single shoot dies; it may be the "leader" or it may be one of the lateral branches. The fungus obtains an entrance into the shoot through some dead part and accumulates a growth in the wood adjacent to the point at which it enters. The resultant effect is the death of that portion of the shoot and the consequent death of the parts above it. The upper parts, above the point of entrance of the fungus, are cut off from the supply of water from below and consequently wither and die; the leaves at first remain attached, but they finally fall or are blown off by

the wind, thus leaving the upper parts of the shoot bare. The primary effect is, then, the death of a certain terminal portion of the shoot; the length of this portion depends upon the distance of the point of entrance of the fungus from the tip of the shoot, it may involve only the uppermost two feet of the shoot or it may involve the greater part of the length of the shoot. After this terminal portion has died, the disease spreads downwards and reaches the base of the shoot. From thence it may spread to the main shoot and down to the trunk, affecting the other branches as it passes downwards and finally killing



Photograph 2.

the tree to its very base. In the photograph 2 a tree is shown with its leading shoot bare of leaves, while the other shoots are apparently healthy. This represents a case in which the "leader" has become attacked by the disease, while the other shoots are not yet affected. In the

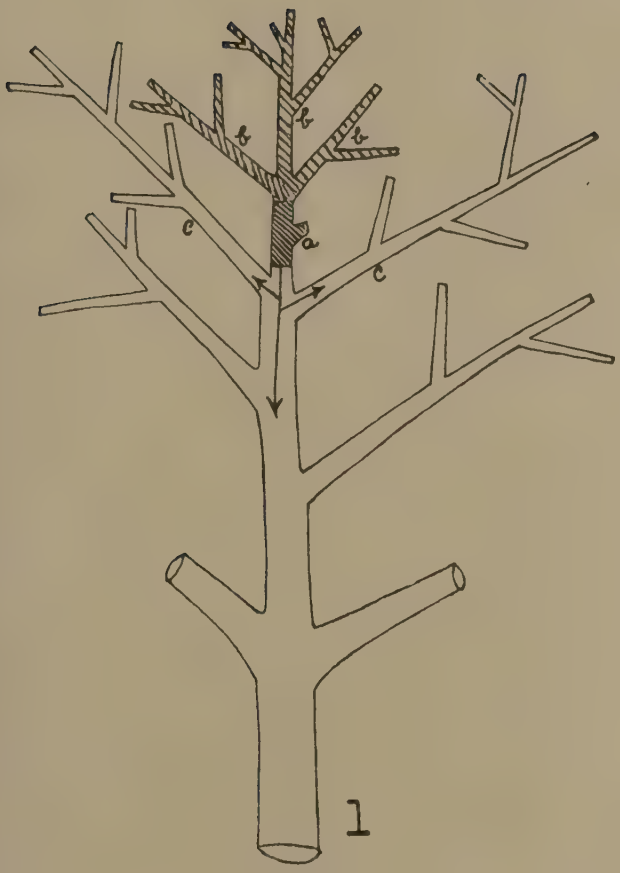


Diagram 1.

diagram 1 the axis of an infected tree is indicated; at *a* the fungus is supposed to have entered through a dead or broken branch and to have accumulated a growth in the wood, as shown by the dark shading; as the result of this the uppermost branches *b* have died (as indicated by a lighter shading in the diagram), and the further progress of the

disease downwards is indicated by the arrows, the branches

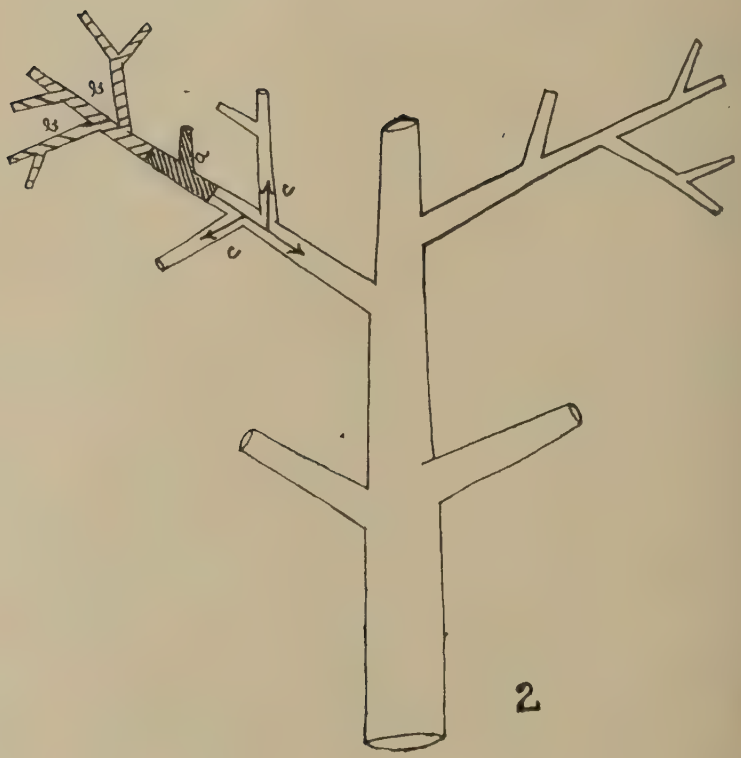


Diagram 2.

c c being the next to die. Diagram 2 represents a similar case, in which the fungus has entered at one of the lateral branches instead of the "leader."

The fungus may enter through a dead or wounded part lower down on the stem. Here it accumulates a

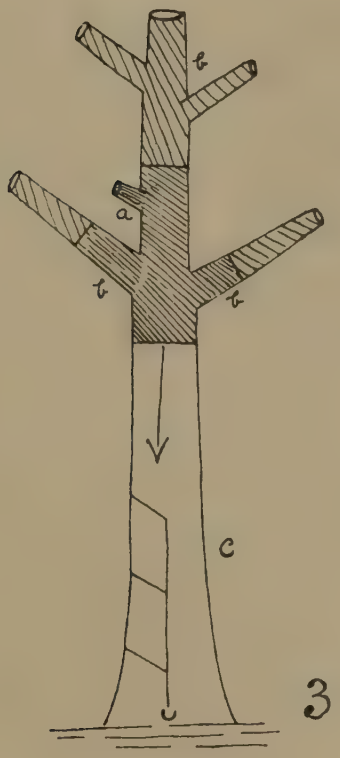


Diagram 3.

growth, as shown at *a* in diagram 3, the resultant effect of which is the death of all of the branches above it, as shown at *b*, the disease then proceeding down the trunk. The

photograph 3 illustrates a case in which the fungus entered low down on the stem, and a broad strip of

Photograph 3.

bark has been removed in order to show the diseased wood. The actual point of entrance is at the scars (broken ends) of two branches shown in the photograph above the

place where the bark has been removed. The death of all three of the branches of the tree seen in the photograph had recently occurred. The death of a large number of branches simultaneously, which occurs when the fungus enters low down on the stem, simulates in appearance the effect of an attack from a root disease; but there is this one important difference, viz. that the parts below are living and continue to yield latex on being tapped, as is indicated at *c* in diagram 3; this is not the case with a root disease.

The above forms of "die-back" are usually met with, the former being more common than the latter. In both cases, however, the symptoms are well-defined, viz. the rapid death of a certain portion of the stem and the subsequent progress of the disease backwards or downwards. In some cases, however, the fungus may enter low down on the stem and may effect the death of the wood slowly; the bark which is external to the area of dead wood dies and the adjacent bark with its cambium makes an attempt to cover over the dead wood, with the result that when the dead bark falls away or is removed a "canker" is exposed to view, *i.e.* an exposed dead area of wood surrounded by a lip of renewing tissue, the product of activity of the cambium. This is a true "canker"—an attempt on the part of the plant to heal a lesion against the action of an organism which tends to keep it open. Such a "canker," resulting from the action of the *Diplodia*, is sometimes, though not frequently met with.

The typical symptoms and progress of the disease have been described above; it remains to describe certain irregularities which sometimes occur. In one case a branch may become infected with the fungus and may die backwards for a certain portion of its length, when an actively growing shoot is produced below the dead part and the dying back ceases. This arrest of the disease has also been met with in seedlings which were infected artificially. Again, a branch may die back to its base and the disease may be checked without proceeding further to the main stem. And thirdly, the fungus may enter through a dead branch, and, instead of accumulating a growth in the wood where it entered, it may proceed down the trunk in a limited area of the wood, with the result that although the fungus may have reached the base of the tree the branches above are not yet dead. The explanation of this is simple and is to the effect that the fungus has not killed off all of the wood at any one part of the trunk; it has not, therefore, at any part of the trunk cut off com-

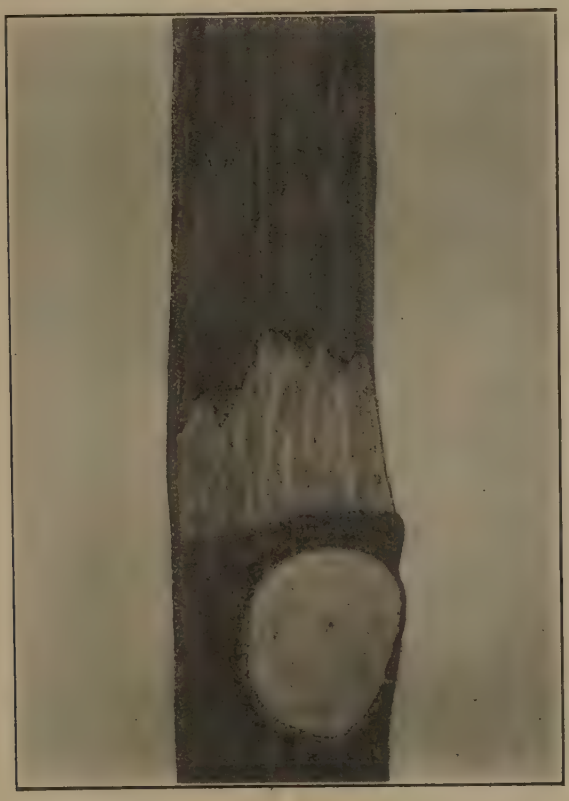
munication between the roots and branches, the branches still continuing to be fed from below through the remaining living wood. An example of this occurs on a tree at the Experimental Gardens at Kuala Lumpur. Attention was first called to the tree by the entrance of borers through the bark, and the area of infected wood on the trunk was traced by cutting into the dead wood and observing the extent of the grey discolouration due to the fungus.

The time taken for a branch to die varies principally according to its size, the position at which the fungus entered and the general condition of health of the plant. Observations have shown that a branch of 2 inches in diameter at its thickest end takes about 8 or 9 weeks to die back from near the tip in an average case. Seedlings, five months of age, were killed in approximately three weeks after inoculation; seedlings, one year old, were killed in about 8 or 9 weeks after inoculation under favourable conditions for growth of the fungus. The time—rate of progress of the disease allows of ample time for observation.

Passing from the external symptoms of disease and death to the appearance presented by the diseased tissues, it will be necessary to describe in some detail the effect of the fungus on the wood and bark and finally the nature of the fruits of the fungus and the appearance of the spores, since these, coupled with the general symptoms and progress of disease, form the means by which the die-back disease is identified.

The wood of an attacked branch shows the symptoms of disease best. As the growth of the fungus proceeds, the wood becomes of grey colour, which is evident on removing the superficial layers of the wood and exposing a cleanly cut surface with a knife. This discolouration may be more evident in the wood of one side of a branch than of another, but it never occurs in streaks and lines as is common in the case of the wood when attacked by another wound fungus, viz. *Eutypa caulivora;* in other words, the effect which is due to the *Diplodia* is a homogeneous grey or dark grey colour in the wood. This is a most important symptom of diagnosis and one that every cultivator should become acquainted with. The death of the wood is always more evident than that of the outer tissues. As the diseased wood is traced downwards, a good line of demarcation can be found between dead and dying tissue; a point is reached where the dark colour of the wood ceases and a brown discolouration becomes evident for a few inches lower

down, beneath which the wood is healthy. The accompany-



Photograph 4.

ing photograph illustrates the line of demarcation between dead and dying tissue in the main axis of a tree which is affected with the disease; the bark has been removed down as far as the cut end of one of the large branches at the fork, and the line of demarcation between dead and dying tissue in the wood is well shown. It has been found by an examination of the wood of an attacked branch that the fungus extends for a distance of a few inches below where the wood is discoloured. It is, therefore, important in amputating a diseased part to cut down to where the wood is healthy and to remove another six inches of the part below this.

Between the wood and bark there is a black mass which was originally the layer of living cambium; this forms a resort for insects of various kinds.

The bark becomes usually of a greyish colour, and, as the disease proceeds, it cracks and peels off, thus exposing the black mass adherent to the surface of the wood.

A brief reference may be made to "bleeding," which has been put forward by some as an indication of the disease. "Bleeding" may occur from various causes, of which the two commoner are the bending of the branches by wind and the pecking of the branches by birds. Parts which are affected with the die-back disease may bleed, but the "bleeding" appears to have little or no connexion with the disease.

After the attacked part of the plant is dead, the fruits of the fungus make their appearance. They take the form of minute black points which burst through the bark and come to the surface; individually they are not visible to the naked eye, but they are usually aggregated in masses in which form they are easily visible to the unaided eye. From these fruits, which are "spore-cases," the spores of the fungus are extruded; and if they are under damp conditions, they may be extruded in large numbers so as to form a sooty black covering on the bark.

Before concluding the symptoms which serve for identification of the disease, it will be necessary to draw attention to some effects which are liable to be confused with the die-back disease. Sometimes trees shed their leaves on one or on all of the branches at irregular periods, *i.e.* at such periods as do not correspond with periods of drought. It not infrequently happens that leafless branches are mistaken for cases of die-back disease, and there has been a tendency to remove all leafless branches whether they are living or dead. It is only necessary to send a coolie up a tree in order to ascertain whether branches are living. And frequently, providing that the tree is not too large, it is possible to ascertain whether branches are living by shaking the trunk of the tree and observing whether the branches bend easily or not; living branches are flexible, while dead branches only bend with some difficulty. The partial or general defoliation of the trees is due to drought, to flooding of the land, to the presence of a peaty bottom soil or to an impervious clay bottom in the subsoil, and to other causes not easily understood at the present state of our knowledge. In some cases the phenomenon appears to precede the period of flowering. The reckless removal of leafless branches must, therefore, be guarded against. Again, as the trees grow older and expand above, the lower branches become shaded and die.

Usually, their leaves become yellow and fall, and they die slowly. During the present dry season, however, such lower branches have been dying off rapidly, their death apparently being accelerated by the dry weather. These branches are not killed by the *Diplodia,* but they form a source of entrance for the *Diplodia* when they are dead. They will be referred to in the section on treatment of the disease.

The die-back disease usually occurs on plantations among individual trees scattered here and there. It seldom occurs on groups of trees; but cases have been recorded in which groups of ten or fifteen trees have been affected simultaneously. Among older trees it is more common, there being in old trees a large number of points of entrance available for the fungus, more especially where pruning is not done and where excessive tapping, close planting and bad cultivation has resulted in a scanty development of foliage and in a weak appearance generally. Among very young rubber the disease is also fairly common, the cut ends of the stumps affording an easy means of entrance for the fungus. Among unhealthy plants generally it is not only more common, but it also does more damage.

Finally, cases have been recorded in which the fungus has entered through the cut ends of roots of stumps which had been lifted for planting. In such cases the fungus gives rise to the ordinary symptoms of a root disease. The occurrence is, however, not common.

SPREAD AND SOURCES OF INFECTION.

In describing the fruits of the fungus above, mention was made of the spores which are extruded from the small black masses on the bark of the affected branches. The spores are minute bodies (about 1/1000 of an inch in diameter) and function as seeds. They are distributed by the wind and are carried by insects which enter the diseased branches; they thus serve to propagate the disease. A spore germinating on a dead part or dead surface of a branch reproduces the mycelium of the fungus which grows in the dead part or surface and spreads to the healthy adjacent parts, thus reproducing the disease. The spores are produced in myriads on dead parts of plants of many kinds, and more especially on those which are recently dead.

Any dead surface, whether it be a dead branch, a wounded branch or a wound on the trunk, affords a means of entrance for the fungus which is itself incapable of entering through a healthy part. It has been shown that at very small wounds, such as would be produced by small insects, the fungus cannot effect an entrance. In other words, it requires a dead surface of appreciable size on which it can accumulate a growth before spreading to the healthy parts.

The wounds and other sources of entrance for the fungus which occur usually on Para rubber plants will be given in some detail thus:—In the planting out of stumps the cut end of each stump presents a wounded surface. When growth commences again, a shoot arises from below this cut end and the portion of the stem above the point of origin of the young shoot dies; this dead part affords a means of entrance for the fungus. "Topping" exposes a wounded surface. Pruning, either "thumb-nail" or the removal of small or large branches, leaves a wound. Other wounds occur, such as those produced by wind, lightning, by animals and by man.

As the trees grow older, the lower branches which have no ready access to the light die; and it is not uncommon to find that the fungus has entered through them and is proceeding to the trunk of the tree.

The highest branches, usually consisting of the end of the main axis of the tree, sometimes become leafless and die. This is commonly met with on badly drained soil, and it appears in other cases to be connected with unsuitable soil conditions or with poverty of the soil. In some cases wind causes a defoliation of the top shoots. Such dead branches as these afford the fungus a means of entrance.

The "pink disease" produces a disintegration of the bark of the stem and exposes the wood beneath. Attacks by the *Diplodia* frequently follow on attacks from the "pink disease."

TREATMENT.

The fungus has been shown to be capable of propagating itself on dead parts of many plants, thus giving rise to spores which serve to spread the disease. The diseased parts of plants and also the dead plant which remains furnish the spores for spread of the disease. These should, therefore, be burnt. Care must be taken to avoid scorching the neighbouring trees, and the fires made must, therefore, be small and must be under control. It is also necessary,

when branches are being burnt, to avoid setting fire to the surrounding masses of leaves and brushwood in dry weather. During a drought a large quantity of the dead branches may be burnt in the drains which in many places are free from water. Dead parts of other plants which are growing along with the rubber, such as coffee and coconuts, should also be burnt. Such a method of sanitation reduces the spore production of the fungus.

The fungus causes greater damage to unhealthy trees than to healthy ones. Attempts should, therefore, be made to ensure a vigorous growth of the plant. By careful pruning and by avoiding close planting, a good access of light should be obtained to all of the branches. By good subsoil drainage the excess of water in the soil and subsoil should be got rid of. The size of drains and their distance apart depends on the nature of the soil; in cases where the land is particularly heavy and lowlying, drains may be made even as close as 1 chain apart. All drains should possess a good gradient and should have a good access to the main drain, care being taken that there is an appreciable flow in the main drain and a good outlet to it. If the land requires "contour" drains, these should be properly marked out with a "tracer" before they are dug. Heavy soils may be reduced and peaty soils neutralised by an application of lime. The lime should be obtained in the form of quick lime, should be placed on the field in heaps and allowed to slake naturally, when it should be spread over the land and turned in. It should not be allowed to become overslaked and pasty. A common application of lime is 15 pikuls per acre; but, for soils rich in organic matter larger quantities may be used.

As a preventive means all wounds should be tarred. The correct tar to use is ordinary coal tar. There has been in some cases in this country an objection raised to the use of coal tar on the pretext that it injures the plant; this objection is entirely unfounded and can only have been imagined or else have arisen through careless application. Before tarring a wound it is necessary to ascertain that the exposed wood is surrounded by bark tissue which is capable of renewing, *i.e.* which is alive. The exposed surface of the wood only should be tarred; the tar should not be allowed to run down the sides of the branch or trunk. The tar should be used cold and should be applied by means of a brush and not with any or every kind of bits of wood. It was previously recommended that the tar should be warmed slightly before using it; this is more advantageous,

but, since warmed tar runs more easily it is, perhaps, best for the coolie to use the tar cold. A smooth surface should be procured for tarring, and, if it is wet, it should be allowed to dry before the tar is applied. Small wounds only require to be tarred once, but in larger wounds a second tarring is advisable sometime after the first.

Care should be taken to tar the cut ends of "stumps" used for planting; and, in order to avoid infection through the broken ends of the roots of "stumps" when they are lifted from the nurseries, it is advisable to expose the roots for as short a time as possible.

Pruning should be carried out systematically and carefully. Superfluous branches at the fork of older trees should be removed in order to allow of a better expansion of the parts above and to get rid of such smaller branches as will eventually die through being shaded and will thus allow the fungus to effect an entrance into the plant. Where the topmost branches are withering it is best to leave them alone and to induce a more vigorous growth by remedying the deficiency in the soil, if this be the cause of defoliation.

All diseased branches should be removed. The indication of the extent of the disease is furnished by the discolouration of the wood. In removing a diseased part it is necessary to cut back to a point where the wood is not discoloured and then to remove another six inches of the part below this. A sloping surface should always be left after removal. Larger branches should be removed by means of a saw. In removing a large branch it will be found advantageous to make more than one cut; first, a cut should be made eight or ten inches from the trunk from below upwards and should go half-way through the branch; then a cut should be made two inches further from the trunk from above downwards and should go through the branch. Finally, the stub should be sawn off flush with the trunk. Stubs should never be left.

"Topping" and deep tapping with consequent exposure of the wood, should always be avoided.

Care should be taken in burning off timber to avoid scorching the neighbouring trees as far as is possible.

This concludes the account of the "die-back disease of *Hevea*," in which the occurrence of the fungus, the symptoms and spread of the disease and the preventive and curative measures to be adopted for its treatment are given in some detail.

A NOTE ON THE LEAF DISEASES OF PARA RUBBER.

Little or no attention has hitherto been paid to the leaf diseases of *Hevea* in the Federated Malay States, and it is for this reason proposed to give a brief summary of the leaf diseases hitherto described on Para rubber from different parts of the world and to call special attention to those which have been found to occur in Malaya.

The leaf diseases of *Hevea* can scarcely be recognised at the present moment as being of any appreciable economic importance. The fungi which affect the leaves of the plant, although they number a dozen, only occur in small quantity; and even in the nurseries, where leaf fungi are wont to cause greater damage than among older plants, the number of affected plants has hitherto been small. Further, in reviewing the leaf diseases of *Hevea,* one factor must be clearly emphasised, and that is the capacity of the plant for shedding and renewing its leaves at any period and with great facility; it is, therefore, easy to observe the difference in the damage caused by a leaf fungus on a leaf of *Hevea,* which can be cast off at any period and with little appreciable loss to the plant, and on a leaf of coffee which is possessed of a comparatively long life and whose loss to the plant can only be remedied with some difficulty. For this reason the leaf fungi which are parasitic on *Hevea* must increase in enormous proportions before they can produce any appreciable effect on the plant.

Hitherto seven fungi have been reported to affect the leaves of *Hevea* in the East and five in the Amazon district. Since all of them produce either a spotting or yellowing of the leaves, they cannot be differentiated by the term "leaf spot" and "yellowing leaf" fungus; they will therefore, have to be called by their specific names.

Pestalozzia Guepini is the commonest leaf fungus in the East. It is the same fungus as causes the "grey blight" of the tea plant and it may therefore be expected to occur in larger quantities in districts where tea is cultivated along with *Hevea.* The fungus produces semi-transparent spots bounded by a narrow reddish brown line. Its action appears to be local and confined to the spots. It is said to kill the seedling when it attacks it at the "collar"; but

hitherto it has not been recorded to attack the stems of the seedlings in the Federated Malay States. On the stems of seedlings in Ceylon it is said to produce a diseased patch which takes the form of a white ring bordered by a narrow reddish brown line.

Pestalozzia Palmarum, a fungus which causes a "leaf spot" of palms throughout the Tropics and which is well known on coconuts in this country, is also said to attack the leaves of *Hevea* in the East; but, it has not been recorded on *Hevea* in the Federated Malay States and its parasitism on *Hevea* is doubtful. Attempts are being made at the present time to inoculate with it. It would appear to be not unlikely that it has been confused with the other species above, *P. Guepini.*

Phyllosticta Heveae was first described from Java and has been found to occur in Ceylon and in Malaya. It produces brownish spots situated usually at the extremities of the leaves.

Helminthosporium Heveae and *Gloeosporium elasticae* have been recorded from Ceylon, but there is hitherto no record of their occurrence in Malaya; in Ceylon also, *Gloeosporium brunneum* and *Colletotrichum Heveae* have been reported to cause the yellowing and dropping of the first two leaves of seedlings. In the Amazon district five leaf fungi are said to occur on *Hevea,* but only one, *Ophiobolus Heveae,* is regarded as being of any importance.

The leaf fungi in Malaya are more commonly met with in the nursery, and it has been shown that not only the fungi, but also the insects, which attack the leaves and shoots of seedlings in the nursery can be effectively warded off by the application of a boiled lime-sulphur mixture. The preparation of the mixture is given in the "Agricultural Bulletin of the Straits Settlements and Federated Malay States," April 1911, p. 114. The mixture should be applied by means of a "Vermorel Eclair" Sprayer, and, by reason of the action of the sulphur contained in the mixture on the reservoir of the machine if it be made of copper, a *tin-lined* "Eclair" must be used. These are supplied by Messrs. A. C. Harper & Co., Kuala Lumpur, and by The Borneo Company, Singapore.

A measure for the control of leaf diseases throughout this country, and one which might well be carried out, is to collect and burn in small heaps all of the leaves which have fallen as soon as the annual period of wintering has commenced. Such a measure would considerably reduce the spore production of the leaf fungi; for such a measure

to have its full effect, however, it would be necessary for everyone systematically to collect and burn as many of the fallen leaves as possible. There appears to be no reason why it should be a costly proceeding and it is hoped that the suggestion will be carefully considered by the planting community.

The following Bulletins have been published by the Department of Agriculture.

1. Notes on *Termes Gestroi* and other species of Termites found on Rubber Estates in the Federated Malay States: by H. C. Pratt, Government Entomologist.

2. Root Diseases of *Hevea braziliensis*, the Para Rubber Tree: by W. J. Gallagher, Government Mycologist.

3. Observations on *Termes Gestroi* as affecting the Para Rubber Tree, and ethods to be employed against its Ravages: by H. C. Pratt, Government Entomologist.

4. A Lepidopterous Pest of Coconuts, *Brachartona catoxantha* Hamps, (Zygaenidae): by H. C. Pratt, Government Entomologist.

5. The Extermination of Rats in Rice-Fields: by W. J. Gallagher, Government Mycologist.

6. A Preliminary note on a Branch and Stem Disease of *Hevea Braziliensis:* by W. J. Gallagher, Government Mycologist.

7. Coffee robusta: by W. J. Gallagher.

8. The Cultivation and Care of the Para Rubber Tree (in Malay).

9. Die-Back Fungus of Para Rubber and of Cacao: by Keith Bancroft, Mycologist.

10. A Lecture on the Para Rubber Tree: by W. J. Gallagher.

11. Coconut Cultivation: by L. C. Brown, Inspector of Coconut Plantations.

12. Padi Cultivation in Krian; by H C. Pratt, Government Entomologist.

13. A Root Disease of Para Rubber, *Fomes Semitostus;* by Keith Bancroft, Assistant Mycologist. (In Preparation).